Morpheus Vertical Test Bed (VTB)/Autonomous Landing and Hazard Avoidance Technology (ALHAT)

Completed Technology Project (2011 - 2014)

Project Introduction

The AES Morpheus Vertical Test Bed (VTB)/Autonomous Landing and Hazard Avoidance Technology (ALHAT) project provided an advanced, reusable, integrated vertical test bed (VTB) platform for developing and maturing multiple human exploration subsystem technologies in a flight-like dynamic environment, including precision landing and hazard avoidance; Guidance, Navigation and Control (GN&C); advanced LOx-Methane propulsion; and other lander technologies.

The Morpheus VTB/ALHAT project free flew a reusable Morpheus VTB with the integrated ALHAT system starting from a slant range of approximately 500 m to the landing target at the KSC Shuttle Landing Field (SLF), ascended to about 250 m and descended to a safe landing site, and demonstrated an autonomous closed-loop landing. This flight demonstrated real-time hazard detection and hazard avoidance, followed by a divert maneuver to the determined safe landing aim point, and a safe, controlled landing within a hazard field. This demonstration flight was a culmination of a series of earlier test flights, starting with improvements to the LOx-Methane propulsion system, GPS navigation, integrated reaction control system, and incrementally increasing in complexity by incorporating ALHAT sensor data. The project yielded not just technologies, but technologies integrated as capabilities that can then be easily adapted to human spaceflight mission architectures.

Anticipated Benefits

The technology has potential benefits and applications for use on the Resolve Prospector Mission and the Mars 2020 mission. The major benefits include development of reusable lander technologies including use of non-toxic propellants; assurance of safe landing sites for crewed or robotic vehicles on any solid planetary body on a wide variety of terrain and surface conditions; improved pin-point landing accuracy; and improved affordability of future spacecraft using these systems.

Project Image Morpheus Vertical Test Bed (VTB)/Autonomous Landing and Hazard Avoidance Technology (ALHAT)

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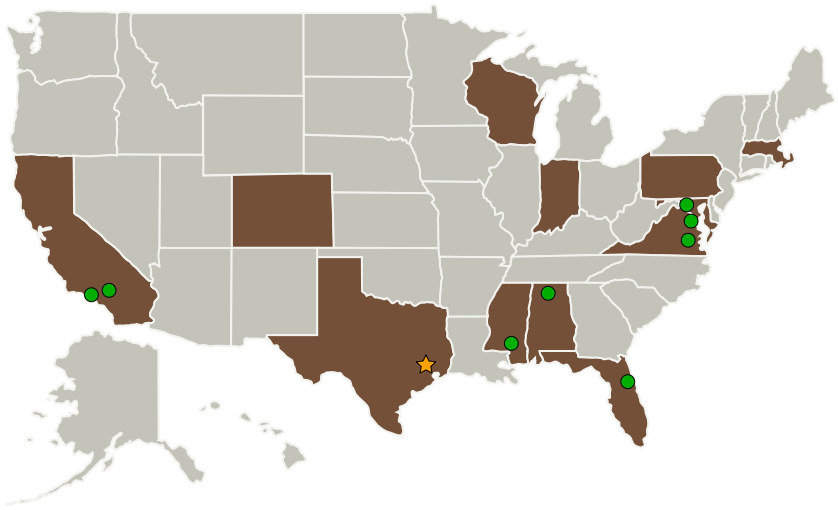
Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Exploration Systems Development Mission Directorate (ESDMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Exploration Capabilities

Project Management

Program Director:

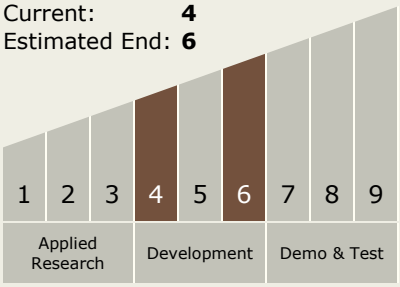
Christopher L Moore

Project Manager:

Jon B Olansen

Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **6**



Technology Areas

Primary:

Continued on following page.

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Organizations Performing Work	Role	Type	Location
★Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
Applied Physics Laboratory	Supporting Organization	Industry	Laurel, Maryland
●Armstrong Flight Research Center(AFRC)	Supporting Organization	NASA Center	Edwards, California
Center for Space Exploration and Technology Research at University of Texas El Paso(cSETR)	Supporting Organization	Academia	El Paso, Texas
●Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland
●Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California
●Kennedy Space Center(KSC)	Supporting Organization	NASA Center	Kennedy Space Center, Florida
L-3 Communications Electron Technology, Inc.	Supporting Organization	Industry	
●Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia
Marquette University	Supporting Organization	Academia	Milwaukee, Wisconsin
●Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Continued on following page.

Technology Areas *(cont.)*

- TX09 Entry, Descent, and Landing
  - TX09.3 Landing
    - TX09.3.1 Touchdown Systems

Target Destinations

The Moon, Mars

Supported Mission Type

Projected Mission (Pull)

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Organizations Performing Work	Role	Type	Location
Microcosm, Inc.	Supporting Organization	Industry Women-Owned Small Business (WOSB)	Hawthorne, California
NASA Headquarters(HQ)	Supporting Organization	NASA Center	Washington, District of Columbia
Oceaneering Space Systems	Supporting Organization	Industry	
Purdue University-Main Campus	Supporting Organization	Academia	West Lafayette, Indiana
Stennis Space Center(SSC)	Supporting Organization	NASA Center	Stennis Space Center, Mississippi
The University of Texas at Austin	Supporting Organization	Academia	Austin, Texas

Co-Funding Partners	Type	Location
Armadillo Aerospace	Industry	
Astrobotic Technology, Inc.	Industry	Pittsburgh, Pennsylvania
Boston Power	Industry	
European Space Agency(ESA)	International	Paris, Outside the United States, France
Jacobs Engineering Group, Inc.	Industry	Dallas, Texas
Masten Space Systems, Inc	Industry	Mojave, California
Space Center Houston Project	Industry	
United Launch Alliance	Industry	

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Primary U.S. Work Locations	
Alabama	California
Colorado	District of Columbia
Florida	Indiana
Maryland	Massachusetts
Mississippi	Pennsylvania
Texas	Virginia
Wisconsin	

Project Transitions

October 2011: Project Start

September 2014: Closed out

Closeout Summary: ALHAT content of this AES project was transferred to the AES project: Lander Technology: ALHAT cap abilities including Navigation Doppler Lidar (NDL) (COBALT) https://techport.nasa.gov/view/93112

Images

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Project Image Morpheus Vertical Test Bed (VTB)/Autonomous Landing and Hazard Avoidance Technology (ALHAT)
(https://techport.nasa.gov/image/40853)

Morpheus FF11
Morpheus Free Flight 11 on April 24, 2014 with ALHAT in open loop
(https://techport.nasa.gov/image/40854)

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Project Website:

http://morpheuslander.jsc.nasa.gov/